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FLUID DIODE EXPANSION DEVICE FOR HEAT PUMPS

BACKGROUND OF THE INVENTION

[0001] This invention relates to an expansion device for a heat pump.

[0002] Heat pumps employ a compressor, an indoor heat exchanger, an outdoor heat exchanger, an expansion device and 4-way reversing valve, to switch operation between cooling and heating modes. Heat pumps utilize an expansion device through which the refrigerant flow expands from high pressure and temperature to low pressure and temperature. Different size restriction of the expansion device is required for proper system operation depending upon whether the heat pump is in a cooling or heating mode of operation. Obviously, when the system is operating in cooling or in heating mode, the direction of the refrigerant flow through the expansion device is reversed.

[0003] Prior art heat pump systems with single expansion devices use a moveable piston that moves in a first direction in which its flow resistance is substantially higher than when it is moved in an opposite second direction. The first direction corresponds to the heating mode and second direction corresponds the cooling mode. The piston is prone to wear, which adversely effects the operation and reliability of the system due to undesirably large tolerances and contamination. Furthermore, modern heat pump systems are incorporating alternate refrigerants, such as R410A, and POE oils. The system utilizing R410A refrigerant operate at much higher pressure differentials than more common R22 and R134A refrigerants employed in the past within the system. This adversely impacts the

expansion device wear, lubrication and results in higher loads during transient conditions of operation.

[0004] Therefore, there is a need for a single reliable, inexpensive expansion device for the heat pump systems that is not as prone to wear and reliability problems.

SUMMARY OF THE INVENTION

[0005] The inventive heat pump expansion device consists of a flow resistance device that has a different resistance to flow depending on the flow direction through this device. The flow resistance device is fixed or rigidly mounted relative to first and second fluid passages so that it avoids the wear problems of the moveable piston in the prior art. The fluid flow resistance device in several examples of the invention is a fixed obstruction about which the refrigerant must flow when traveling through the expansion device. The flow resistance device has features on one side that create a low drag coefficient when the refrigerant flows in one direction but a high drag coefficient when the refrigerant flows in the opposing direction.

[0006] Accordingly, the present invention provides a reliable, inexpensive expansion device that is not as prone to wear and reduces reliability problems.

[0007] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figure 1 is a schematic view of a heat pump having the inventive expansion device.

[0009] Figure 2 to a cross-sectional view of a first example of the inventive expansion device.

[0010] Figure 3 is a cross-sectional view of second example of the inventive expansion device.

[0011] Figure 4 is a cross-sectional view of a third example of the inventive expansion device.

[0012] Figure 5 is a cross-sectional view of a fourth exampled of the inventive expansion device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0013] A heat pump 10 utilizing the present invention and capable of operating in both cooling and heating modes is shown schematically in Figure 1. The heat pump 10 includes a compressor 12. The compressor 12 delivers refrigerant through a discharge port 14 that is returned back to the compressor through a suction port 16.

[0014] Refrigerant moves through a four-way valve 18 that can be switched between heating and cooling positions to direct the refrigerant flow in a desired manner (indicated by the arrows associated with valve 18 in Figure 1) depending upon the requested mode of operation, as is well known in the art. When the valve 18 is positioned in the

cooling position, refrigerant flows from the discharge port 14 through the valve 18 to an outdoor heat exchanger 20 where heat from the compressed refrigerant is rejected to a secondary fluid, such as air. The refrigerant flows from the outdoor heat exchanger 20 through a first fluid passage 26 of the inventive expansion device 22. The refrigerant when flowing in this forward direction expands as it moves from the first fluid passage to a second fluid passage 28 thereby reducing its pressure and temperature. The expanded refrigerant flows through an indoor heat exchanger 24 to accept heat from another secondary fluid and supply cold air indoors. The refrigerant returns from the indoor exchanger 24 to the suction port 16 through the valve 18.

[0015] When the valve 18 is in the heating position, refrigerant flows from the discharge port 14 through the valve 18 to the indoor heat exchanger 24 where heat is rejected to the indoors. The refrigerant flows from the indoor heat exchanger 24 through second fluid passage 28 to the expansion device 22. As the refrigerant flows in this reverse direction from the second fluid passage 28 through the expansion device 22 to the first fluid passage 26, the refrigerant flow is more restricted in this direction as compared to the forward direction. The refrigerant flows from the first fluid passage 26 through the outdoor heat exchanger 20, four-way valve 18 and back to the suction port 16 through the valve 18.

[0016] Several examples of the inventive expansion device are shown in Figures 2-6. The inventive expansion device 22 includes a flow resistance device 30 that is arranged between the first 26 and second 28 fluid passages. Unlike the prior art moveable piston, the flow resistance device 30 is fixed relative to the fluid passages 26 and 28 so that it does not have any features that are subject to damage, wear or contamination. The flow resistance

device 30 is shown schematically supported by a pin. The flow resistance device 30 has lower fluid resistance when the refrigerant is flowing in the forward or cooling direction than when refrigerant is flowing in the reverse or heating direction, acting as a fluid diode. This variable fluid resistance is achieved by providing different features on either side of the flow resistance device 30 that increases the fluid resistance in one direction and provides lower fluid resistance in the other direction.

[0017] Referring to Figure 2, the flow resistance device 30 includes a barbed end 32 facing the second fluid passage 28. When the refrigerant is flowing in the forward or cooling direction, the refrigerant flows about smooth surfaces of the flow resistance device 30 so that the arrangement of the flow resistance device 30 between the passages 26 and 28 creates relatively little resistance. However, when the refrigerant flows in the reverse order or heating direction, the refrigerant flows into the barbed end 32 creating a very high drag or resistance to the fluid flow.

[0018] Another example of the invention is shown in Figure 3, which utilizes an angled fluid passage 34 as the flow resistance device 30. The angled fluid passage 34 is arranged such that refrigerant flowing in the cooling direction generally bypasses the angled fluid passage 34 flowing more directly through to the second fluid passage 28. However, when the refrigerant flows in the heating direction the refrigerant more easily flows into the angled fluid passage 34 due to its orientation relative to the second fluid passage 28. Fluid flow from the second fluid passage 28 into the entry of the angled fluid passage 34 is better maintained due to the shallow angle of the wall between the second fluid passage 28 and the wall at the opening of the angled fluid passage 34. The refrigerant exits the angled fluid

passage 34 in such a manner that it is directed back into the flow of refrigerant flowing from the second fluid passage 28 to the first fluid passage 26 creating turbulence and generating an increased flow resistance as compared to refrigerant flowing in the cooling direction.

[0019] Referring to Figures 4 and 5, the flow resistance device 30 is arranged between the fluid passages 26 and 28 in a similar manner to that shown in Figure 2. As shown in Figure 4, the flow resistance device 30 is an open faced hemisphere 38, and the flow resistance device 30 shown in Figure 5 is a C-shaped channel 40 arranged between the fluid passages 26 and 28. As the refrigerant flows in the cooling direction, the smooth rounded surface of the flow resistance devices 30 have a relatively low drag coefficient. However, when the refrigerant flows in the heating direction into the cupped area of the flow resistance devices 30, a relatively high drag coefficient is experienced increasing the flow resistance in the heating direction.

[0020] It should be appreciated that the flow resistances can be expressed using various terminology. For example, the flow resistances can be expressed as drag coefficients. The flow resistances can also be expressed as relative degrees of turbulent or laminar flows. In any event, the change in flow resistance based upon the direction of refrigerant flow is achieved by utilizing a fixed flow resistance device.

[0021] Although a preferred embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.